

Potential impact of “omics” and other emerging genetic technologies on NOAA’s mission

David M. Lodge, Susan Avery, David L. Fluharty, and Jeremy Jackson

Technologies in molecular biology have recently become powerful and relatively inexpensive tools to improve: surveillance and monitoring of the occurrence of organisms in natural environments (Kelly et al. 2014a, Kelly et al. 2014b); measuring and analyzing the biophysical functioning of organisms and ecosystems; understanding of how organism’s physiology and health respond to changing environmental conditions; *and* management of species, including changes in their DNA. The “-omics” help accomplish the first three goals, while gene editing and gene drives change the DNA of organisms for management goals.

“omics” to improve surveillance, monitoring or occurrence, functioning, and health of organisms

In general, “omics” refers to **genomics** (study of the entire set of genes and other information encoded in the DNA of an organism), **transcriptomics** (the study of all the messenger RNA molecules in an organism, which indicates the environment-specific expression of the genome), and **proteomics** (the study of all the proteins produced by an organism). Rapid increases in the speed, and decreases in the cost of these technologies has led to their increasing use to diagnose, for example, which microorganisms are present, which nutrients are in shortest supply, and what other stresses, limitations, or diseases are affecting organisms’ physiology and functioning in their environment, e.g., HABs. Most recently, improvements in **gene editing** technologies to alter the genome (and thus alter the transcriptome and proteome) have garnered great attention, and are being employed or planned for a wide range of environmental management goals as well as hoped-for economically profitable activities including aquaculture, and biomedical applications.

Gene editing and gene drives to manage organisms

Time magazine’s 23 June 2016 cover story on gene editing declared: “One of the most exciting breakthroughs in science is here. CRISPR is a new technology that can edit DNA with remarkable precision, and it has the potential to change human lives forever . . . CRISPR is already being used on crops, insects and more” (Park 2016). Applications could certainly involve fishes and other marine species for which NOAA has responsibility.

When these gene editing technologies are used to alter the germ cells of an organism, they become heritable. When germ cell editing is combined with a **gene drive**, the genetic modification sweeps through the species’ population, replacing all variants of the target gene with the desired version of the gene (which can be, for example, a lethal gene leading to the extirpation of the species).

While *Time* was almost breathless in its enthusiasm for applications of gene editing and gene drives, many scientists have been cautious, especially about gene drives, which may deliver harmful side effects as well as potential benefits in many applications ([NASEM 2016](#) ; [Specter 2016](#)). Applications of gene editing and gene drives do or may include modification of fishes or other species to confer more desirable traits for human exploitation; make species more tolerant of changing conditions (e.g., temperature, pH, salinity); confer resistance to pathogens or parasites; and eradication of parasites, pathogens, vectors of disease, and other harmful species, including invasive species.

Recommendations for NOAA

Environmental applications for omics, gene editing, and gene drives are likely to have increasing relevance to that part of NOAA's mission **"to conserve and manage coastal and marine ecosystems and resources."** Because NOAA's capacity to develop and apply or even evaluate and communicate about these new technologies is likely to be limited by slow changes in the NOAA scientific workforce, **we recommend that NOAA invite multiple speakers to one or more SAB meetings to increase the knowledge of NOAA leadership about these technologies, when/where they are likely to provide opportunities and/or challenges to the NOAA mission, and what existing or future governance mechanisms exist for these technologies with respect to the NOAA mission.** Speakers and subsequent discussion by the SAB and leadership are likely to lead to further, more specific recommendations about NOAA research and regulatory planning and activities, priorities for future NOAA Cooperative Institutes, and the future NOAA workforce.

Suggested potential speakers:

James P. Collins, School of Life Sciences, Arizona State University, ecologist who co-chaired 2016 NAS study on gene drives, former NSF division director.

Ruth Gates, U Hawaii Institute of Marine Biology, coral acclimation and adaptation to climate change, coral microbiome.

Kelly Goodwin, NOAA Southwest Fisheries Science Center, 'OMICS Transformational Tools, Systematically applied

Gregory E. Kaebnick, The Hasting Center, philosopher, ethicist; member of NAS gene drive committee. Ethics, cost-benefit, risk assessment of synthetic biology.

Ryan Kelly, School of Marine and Environmental Affairs, University of Washington -- PhD in marine genomics, JD from Berkeley.

Simon A. Levin, Dept of Ecology and Evolutionary Biology, Princeton University—ecologist, NAS member

Linda Rhodes, NOAA Northwest Fisheries Science Center, Environmental sample processor – robotic application of ' omics.

Forest Rohrer, Biology Dept, San Diego State U, microbial ecologists using metagenomics to study bacteria and viruses as a major player in coral reefs and other marine communities.

Mark Saito, WHOI, iron and other limitations of marine phytoplankton studied with proteomics and metagenomics; informatics; Moore Foundation Fellow.

Joseph Travis, Dept. of Biological Sciences, Florida State U., ecologist, served on NAS gene drive committee, evolution of life histories in fishes

Madeleine van Oppen, School for BioSciences, U of Melbourne, ARC Centre of Excellence for Coral Reef Studies. microbial symbiosis in corals, adaptation/acclimatisation to climate change, genetic manipulations to enhance stress tolerance and fitness of corals

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